

NASA/TM—2000–209891, Vol. 141



**Technical Report Series on the
Boreal Ecosystem-Atmosphere Study (BOREAS)**

Forrest G. Hall and Shelaine Curd, Editors

Volume 141

**BOREAS TE-5 Surface Meteorological
and Radiation Data**

J. Ehleringer, J.R. Brooks, and L. Flanagan

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

October 2000

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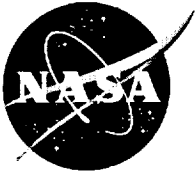
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**BOREAS TE-5 Surface Meteorological
and Radiation Data**

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BOREAS TE-5 Surface Meteorological and Radiation Data

Jim Ehleringer, J.Renee Brooks, Larry Flanagan

Summary

The BOREAS TE-5 team collected measurements in the NSA and SSA on gas exchange, gas composition, and tree growth. Measurements of meteorological data, including air and soil temperature, RH, and PPFD, were 30-minute intervals during the 1994 IFCs at various sites in the BOREAS NSA and SSA. The data are provided in tabular ASCII files.

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1. Data Set Overview

1.1 Data Set Identification

BOREAS TE-05 Surface Meteorological and Radiation Data

1.2 Data Set Introduction

Basic meteorological data (air and soil temperature, relative humidity (RH), and photosynthetic photon flux density (PPFD) data) were collected at varying heights in the BOREal Ecosystem-Atmosphere Study (BOREAS) Northern Study Area (NSA) and Southern Study Area (SSA) sites.

1.3 Objective/Purpose

The data were collected to provide basic meteorological information at the sampling sites during times when Terrestrial Ecology (TE)-05 team sampled canopy CO₂ for carbon and oxygen isotope analysis.

1.4 Summary of Parameters

Date, Julian Day, Time Greenwich Mean Time ((GMT) h), Temp at RH sensor (C), midcanopy RH%, 9-m PPFD micromoles/m²/s, 1-m PPFD, 9-m Tair (C), 1-m Tair (C), 10-cm Tsoil(C), and 20-cm Tsoil (C) collected at 30-min intervals.

1.5 Discussion

These measurements were made at both the NSA and the SSA during each Intensive Field Campaign (IFC) at the Old Jack Pine (OJP), Old Black Spruce (OBS), T6R5S TE Upland Black Spruce (UBS), and Old Aspen (OA).

1.6 Related Data Sets

BOREAS TE-05 Diurnal CO₂ Canopy Profile Data
BOREAS TE-05 Leaf Gas Exchange Data
BOREAS TE-05 Leaf Carbon Isotope Data
BOREAS TE-05 Tree Ring and Carbon Isotope Ratio Data
BOREAS TE-05 Air Stable Isotope

2. Investigator(s)

2.1 Investigator(s) Name and Title

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TE-05
Department of Biology
Salt Lake City, UT 84112

Dr. Larry Flanagan
Department of Biological Sciences
University of Lethbridge
4401 University Drive
Lethbridge, Alberta T1K 3M4, CANADA

2.2 Title of Investigation

Vegetation-Atmosphere CO₂ and H₂O Exchange Processes: Stable Isotope Analyses

2.3 Contact Information

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Lethbridge, Alberta
T1K 3M4, CANADA
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3. Theory of Measurements

Surface meteorological and radiation data were taken in conjunction with CO₂ isotope data collections by TE-05.

4. Equipment

4.1 Sensor/Instrument Description

- RH: The Campbell Scientific, Inc., 207 Temperature and RH probe contains a Phys-Chem Scientific, Inc., PCRC-11 RH sensor and a Fenwal Electronics UUT51J1 thermistor. The combined RH sensor accuracy is typically better than 5% over the 12-100% RH range.
- PPFD: Hamamatsu GaAsP Photodiodes G1118 calibrated with a LI-COR Quantum sensor. Each sensor was mounted on a flat white platform and then mounted to the Rohn mast and leveled with a bubble level.
- Temperature: Copper constantan thermocouples.
- A Campbell CR-21x data logger was used to record the meteorological data.

4.1.1 Collection Environment

The data were collected under ambient conditions during the collection period.

4.1.2 Source/Platform

Meteorological data were collected from a Rohn mast extending 9 m up into the canopy.

4.1.3 Source/Platform Mission Objectives

The objective was to monitor basic meteorological data within the forest canopy at the location where the TE-05 team collected CO₂ for isotope analysis.

4.1.4 Key Variables

Date, Julian Day, Time (GMT h), Temp at RH sensor (C), midcanopy RH%, 9-m PPFD micromoles/m²/s, 1-m PPFD, 9-m Tair (C), 1-m Tair (C), 10-cm Tsoil(C), and 20-cm Tsoil (C) collected at 30-minute intervals.

4.1.5 Principles of Operation

All sensors were attached to a Campbell CR-21x data logger and monitored every 30 minutes.

4.1.6 Sensor/Instrument Measurement Geometry

None given.

4.1.7 Manufacturer of Sensor/Instrument

207 Temperature and RH probe

CR-21x data logger

Campbell Scientific, Inc.

P.O. Box 551

Logan, UT 84321

(801) 753-2342

Hamamatsu GaAsP Photodiodes G1118

Hamamatsu Corporation

360 Foothill Road

P.O. Box 6910

Bridgewater, NJ 08807-0910

(201) 231-0960

Copper Constantan Thermocouples

Omega Engineering

P.O. Box 1

Broughton Astley Leicestershire

LE9 6XR, England

(800) 826-6342

4.2 Calibration

4.2.1 Specifications

None given.

4.2.1.1 Tolerance

The RH probe contains a Phys-Chem Scientific, Inc., PCRC-11 RH Sensor and Fenwal Electronics UUT51J1 thermistor. The combined RH sensor accuracy is typically better than 5% over the 12-100% RH range.

4.2.2 Frequency of Calibration

All instruments were calibrated and tested in the lab prior to the first IFC.

4.2.3 Other Calibration Information

During each IFC, instruments were checked for placement and orientation but were not recalibrated.

5. Data Acquisition Methods

All sensors were attached to a Campbell CR-21x data logger and monitored every 30 minutes. Note that the 9-m Rohn mast was shorter than the canopy at the SSA-OJP, SSA-OA, and NSA-OA sites.

6. Observations

6.1 Data Notes

None given.

6.2 Field Notes

The RH sensor for NSA-OA during IFC-3 was not operational.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

The North American Datum of 1983 (NAD83) coordinates of the sites are:

- NSA-OJP flux tower site: Lat/Long: 55.927°N, 98.62°W, Universal Transverse Mercator (UTM) Zone 14, N:6, 197,997 E:523,501.
- NSA-OA canopy access tower site: auxiliary site number T2Q6A, BOREAS Experiment Plan, Version 3, Lat/Long = 55.88°N, 98.67°W.
- NSA-UBS canopy access tower site: auxiliary site number T6R5S, BOREAS Experiment Plan, Version 3, Lat/Long = 55.70°N, 98.51°W.
- SSA-OJP: Lat/Long: 53.91°N, 104.69°W, UTM Zone 13, 53.91634 N, 104.69203 W.
- SSA-OBS: Lat/Long: 53.98°N, 105.12°W, UTM Zone 13, 5982100.5 N, 492276.5 E.
- SSA-OA: Lat/Long: 53.62°N, 106.19°W. UTM Zone 13, 5942899.9 N, 420790.5 E

7.1.2 Spatial Coverage Map

None given.

7.1.3 Spatial Resolution

These are point source measurements at the locations given.

7.1.4 Projection

None given.

7.1.5 Grid Description

None given.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

The data were collected from 25-May-1994 to 08-Sep-1994.

7.2.2 Temporal Coverage Map

IFC-1:

NSA-OJP: 02-Jun-1994, 7.32 Greenwich Mean Time (GMT) through 03-Jun-1994, 16.32 (GMT).

NSA-OA: 10-Jun-1994, 16.15 (GMT) through 11-Jun-1994, 19.98 (GMT).

NSA-UBS: 03-Jun-1994, 2.15 (GMT) through 4-Jun-1994, 2.15 (GMT).

SSA-OA: 29-May-1994, 1900 (GMT) through 30-May-1994, 2150 (GMT).

SSA-OBS: 25-May-1994, 1.50 (GMT) through 27-May-1994, 20.00 (GMT).

SSA-OJP: 25-May-1994, 2050 (GMT) through 27-May-1994, 2.00 (GMT).

IFC-2:

NSA-OJP: 20-Jul-1994, 21.48 (GMT) through 24-Jul-1994, 22.32 (GMT).
 NSA-OA: 31-Jul-1994, 17.82 (GMT) through 05-Aug-1994, 20.98 (GMT).
 NSA-UBS: 25-Jul-1994, 20.15 (GMT) through 29-Jul-1994, 22.48 (GMT).
 SSA-OA: 25-Jul-1994, 1900 (GMT) through 27-Jul-1994, 17.50 (GMT).
 SSA-OBS: 20-Jul-1994 20.50 (GMT) through 22-Jul-1994, 15.50 (GMT).
 SSA-OJP: 22-Jul-1994, 2.50 (GMT) through 24-Jul-1994, 18.00 (GMT).

IFC-3:

NSA-OJP: 30-Aug-1994, 18.65 (GMT) through 01-Sep-1994, 21.15 (GMT).
 NSA-OA: 05-Sep-1994, 19.32 (GMT) through 07-Sep-1994, 18.65 (GMT).
 NSA-UBS: 02-Sep-1994, 18.48 (GMT) through 04-Sep-1994, 16.15 (GMT).
 SSA-OA: 03-Aug-1994, 17.50 (GMT) through 05-Sep-1994, 18.00 (GMT).
 SSA-OBS: 31-Aug-1994, 18.50 (GMT) through 02-Aug-1994, 17.50 (GMT).
 SSA-OJP: 06-Aug-1994, 18.00 (GMT) through 08-Aug-1994, 18.50 (GMT).

7.2.3 Temporal Resolution

Meteorological measurements were made every 30 minutes.

7.3 Data Characteristics**7.3.1 Parameter/Variable**

The parameters contained in the data files on the CD-ROM are:

Column Name
SITE_NAME
SUB_SITE
DATE_OBS
TIME_OBS
AIR_TEMP_AT_REL_HUM_SENSOR
REL_HUM_6M
REL_HUM_9M
PPFD_1M
PPFD_9M
AIR_TEMP_1M
AIR_TEMP_9M
SOIL_TEMP_10CM
SOIL_TEMP_20CM
CRTFCN_CODE
REVISION_DATE

7.3.2 Variable Description/Definition

The descriptions of the parameters contained in the data files on the CD-ROM are:

Column Name	Description
SITE_NAME	The identifier assigned to the site by BOREAS, in the format SSS-TTT-CCCCC, where SSS identifies the portion of the study area: NSA, SSA, REG, TRN, and TTT identifies the cover type for the site, 999 if unknown, and CCCCC is the identifier for site, exactly what it means will vary with site type.

SUB_SITE	The identifier assigned to the sub-site by BOREAS, in the format GGGGG-III, where GGGGG is the group associated with the sub-site instrument, e.g. HYD06 or STAFF, and III is the identifier for sub-site, often this will refer to an instrument.
DATE_OBS	The date on which the data were collected.
TIME_OBS	The Greenwich Mean Time (GMT) when the data were collected.
AIR_TEMP_AT_REL_HUM_SENSOR	The air temperature at the relative humidity sensor.
REL_HUM_6M	The relative humidity at 6 meters above ground level.
REL_HUM_9M	The relative humidity at 9 meters above ground level.
PPFD_1M	Photosynthetic Photon Flux Density at 1 meter above ground level.
PPFD_9M	Photosynthetic Photon Flux Density at 9 meters above ground level.
AIR_TEMP_1M	The temperature of the air as taken 1 meter above ground level.
AIR_TEMP_9M	Air temperature at 9 meters above ground level.
SOIL_TEMP_10CM	Soil temperature at 10 cm depth.
SOIL_TEMP_20CM	Soil temperature at 20 cm depth.
CRTFCN_CODE	The OREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).
REVISION_DATE	The most recent date when the information in the referenced data base table record was revised.

7.3.3 Unit of Measurement

The measurement units for the parameters contained in the data files on the CD-ROM are:

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
DATE_OBS	[DD-MON-YY]
TIME_OBS	[HHMM GMT]
AIR_TEMP_AT_REL_HUM_SENSOR	[degrees Celsius]
REL_HUM_6M	[percent]
REL_HUM_9M	[percent]
PPFD_1M	[micromoles][meter ⁻²][second ⁻¹]
PPFD_9M	[micromoles][meter ⁻²][second ⁻¹]
AIR_TEMP_1M	[degrees Celsius]
AIR_TEMP_9M	[degrees Celsius]
SOIL_TEMP_10CM	[degrees Celsius]
SOIL_TEMP_20CM	[degrees Celsius]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

7.3.4 Data Source

The source of the parameter values contained in the data files on the CD-ROM are:

Column Name	Data Source
SITE_NAME	[BORIS Designation]
SUB_SITE	[BORIS Designation]
DATE_OBS	[Human Observer]
TIME_OBS	[Human Observer]
AIR_TEMP_AT_REL_HUM_SENSOR	[Thermometer]
REL_HUM_6M	[Field Equipment]
REL_HUM_9M	[Field Equipment]
PPFD_1M	[Field Equipment]
PPFD_9M	[Field Equipment]
AIR_TEMP_1M	[Thermometer]
AIR_TEMP_9M	[Thermometer]
SOIL_TEMP_10CM	[Thermometer]
SOIL_TEMP_20CM	[Thermometer]
CRTFCN_CODE	[BORIS Designation]
REVISION_DATE	[BORIS Designation]

7.3.5 Data Range

The following table gives information about the parameter values found in the data files on the CD-ROM.

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SITE_NAME	NSA-9BS-9TETR	SSA-OJP-FLXTR	None	None	None	None
SUB_SITE	9TE05-MET01	9TE05-MET01	None	None	None	None
DATE_OBS	25-MAY-94	08-SEP-94	None	None	None	None
TIME_OBS	0	2330	None	None	None	None
AIR_TEMP_AT_REL_HUM_SENSOR	-3.08	29.81	None	None	None	Blank
REL_HUM_6M	24.04	102.1	None	None	None	Blank
REL_HUM_9M	13.57	103	None	None	None	Blank
PPFD_1M	-1.949	1387	None	None	None	Blank
PPFD_9M	-5.677	1827	None	None	None	None
AIR_TEMP_1M	-3.521	30.92	None	None	None	None
AIR_TEMP_9M	.62	33.37	None	None	None	None
SOIL_TEMP_10CM	-.244	21.92	None	None	None	Blank
SOIL_TEMP_20CM	-.138	18.55	None	None	None	Blank
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	07-DEC-97	07-DEC-97	None	None	None	None

Minimum Data Value -- The minimum value found in the column.

Maximum Data Value -- The maximum value found in the column.

Missng Data Value -- The value that indicates missing data. This is used to indicate that an attempt was made to determine the parameter value, but the attempt was unsuccessful.

Unrel Data Value -- The value that indicates unreliable data. This is used to indicate an attempt was made to determine the parameter value, but the value was deemed to be unreliable by the analysis personnel.

Below Detect Limit -- The value that indicates parameter values below the instruments detection limits. This is used to indicate that an attempt was made to determine the parameter value, but the analysis personnel determined that the parameter value was below the detection limit of the instrumentation.

Data Not Clcltd -- This value indicates that no attempt was made to determine the parameter value. This usually indicates that BORIS combined several similar but not identical data sets into the same data base table but this particular science team did not measure that parameter.

Blank -- Indicates that blank spaces are used to denote that type of value.

N/A -- Indicates that the value is not applicable to the respective column.

None -- Indicates that no values of that sort were found in the column.

7.4 Sample Data Record

The following are wrapped versions of data record from a sample data file on the CD-ROM.

```
SITE_NAME,SUB_SITE,DATE_OBS,TIME_OBS,AIR_TEMP_AT_REL_HUM_SENSOR,REL_HUM_6M,
REL_HUM_9M,PPFD_1M,PPFD_9M,AIR_TEMP_1M,AIR_TEMP_9M,SOIL_TEMP_10CM,SOIL_TEMP_20CM,
CRTFCN_CODE,REVISION_DATE
'NSA-OJP-FLXTR','9TE05-MET01',02-JUN-94,100,18.64,40.94,,38.92,515.1,19.98,17.77,
7.59,7.46,'CPI',07-DEC-97
'NSA-OJP-FLXTR','9TE05-MET01',02-JUN-94,130,18.26,41.67,,33.53,407.1,20.26,16.63,
7.69,7.59,'CPI',07-DEC-97
```

8. Data Organization

8.1 Data Granularity

The smallest unit of orderable data is data collected on one day at one site.

8.2 Data Format(s)

The Compact Disk-Read-Only Memory (CD-ROM) files contain American Standard Code for Information Interchange (ASCII) numerical and character fields of varying length separated by commas. The character fields are enclosed with single apostrophe marks. There are no spaces between the fields.

Each data file on the CD-ROM has four header lines of Hyper-Text Markup Language (HTML) code at the top. When viewed with a Web browser, this code displays header information (data set title, location, date, acknowledgments, etc.) and a series of HTML links to associated data files and related data sets. Line 5 of each data file is a list of the column names, and line 6 and following lines contain the actual data.

9. Data Manipulations

9.1 Formulae

None.

9.1.1 Derivation Techniques and Algorithms

None.

9.2 Data Processing Sequence

None given.

9.2.1 Processing Steps

None given.

9.2.2 Processing Changes

None given.

9.3 Calculations

None.

9.3.1 Special Corrections/Adjustments

The millivolt signal from the photodiodes was converted into PPFD using the following equation:

$$\text{PPFD} = -1.4 + 71.3 \text{ mv} \quad R^2=0.999$$

This equation was derived from a comparison between a LI-COR quantum sensor and all the photodiodes used in the field. The same equation was used for all photodiode sensors.

9.3.2 Calculated Variables

$$\text{PPFD} = -1.4 + 71.3 \text{ mv} \quad R^2=0.999$$

9.4 Graphs and Plots

None given.

10. Errors

10.1 Sources of Error

The Rohn masts that the light sensors were attached to were not perfectly vertical, so 9-m PPFD sensors were not perfectly horizontal.

10.2 Quality Assessment

None given.

10.2.1 Data Validation by Source

None given.

10.2.2 Confidence Level/Accuracy Judgment

None given.

10.2.3 Measurement Error for Parameters

None given.

10.2.4 Additional Quality Assessments

None given.

10.2.5 Data Verification by Data Center

Data were examined for general consistency and clarity.

11. Notes

11.1 Limitations of the Data

None given.

11.2 Known Problems with the Data

All known problems have been removed.

11.3 Usage Guidance

None given.

11.4 Other Relevant Information

None.

12. Application of the Data Set

The data can be used for meteorological and radiation comparison during IFCs, particularly when TE-05 sampled canopy CO₂ for carbon and oxygen isotope analysis.

13. Future Modifications and Plans

None given.

14. Software

14.1 Software Description

None given.

14.2 Software Access

None given.

15. Data Access

The surface meteorological and radiation data are available from the Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

15.1 Contact Information

For BOREAS data and documentation please contact:

ORNL DAAC User Services
Oak Ridge National Laboratory
P.O. Box 2008 MS-6407
Oak Ridge, TN 37831-6407
Phone: (423) 241-3952
Fax: (423) 574-4665
E-mail: ornl_daac@ornl.gov or ornl@eos.nasa.gov

15.2 Data Center Identification

Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) for Biogeochemical Dynamics
<http://www-eosdis.ornl.gov/>.

15.3 Procedures for Obtaining Data

Users may obtain data directly through the ORNL DAAC online search and order system [<http://www-eosdis.ornl.gov/>] and the anonymous FTP site [<ftp://www-eosdis.ornl.gov/data/>] or by contacting User Services by electronic mail, telephone, fax, letter, or personal visit using the contact information in Section 15.1.

15.4 Data Center Status/Plans

The ORNL DAAC is the primary source for BOREAS field measurement, image, GIS, and hardcopy data products. The BOREAS CD-ROM and data referenced or listed in inventories on the CD-ROM are available from the ORNL DAAC.

16. Output Products and Availability

16.1 Tape Products

None.

16.2 Film Products

None.

16.3 Other Products

These data are available on the BOREAS CD-ROM series.

17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation

None given.

17.2 Journal Articles and Study Reports

Newcomer, J., D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers, eds. 2000. Collected Data of The Boreal Ecosystem-Atmosphere Study. NASA. CD-ROM.

Sellers, P. and F. Hall. 1994. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1994-3.0, NASA BOREAS Report (EXPLAN 94).

Sellers, P. and F. Hall. 1996. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1996-2.0, NASA BOREAS Report (EXPLAN 96).

Sellers, P., F. Hall, and K.F. Huemmrich. 1996. Boreal Ecosystem-Atmosphere Study: 1994 Operations. NASA BOREAS Report (OPS DOC 94).

Sellers, P., F. Hall, and K.F. Huemmrich. 1997. Boreal Ecosystem-Atmosphere Study: 1996 Operations. NASA BOREAS Report (OPS DOC 96).

Sellers, P., F. Hall, H. Margolis, B. Kelly, D. Baldocchi, G. den Hartog, J. Cihlar, M.G. Ryan, B. Goodison, P. Crill, K.J. Ranson, D. Lettenmaier, and D.E. Wickland. 1995. The boreal ecosystem-atmosphere study (BOREAS): an overview and early results from the 1994 field year. Bulletin of the American Meteorological Society. 76(9):1549-1577.

Sellers, P.J., F.G. Hall, R.D. Kelly, A. Black, D. Baldocchi, J. Berry, M. Ryan, K.J. Ranson, P.M. Crill, D.P. Lettenmaier, H. Margolis, J. Cihlar, J. Newcomer, D. Fitzjarrald, P.G. Jarvis, S.T. Gower, D. Halliwell, D. Williams, B. Goodison, D.E. Wickland, and F.E. Guertin. 1997. BOREAS in 1997: Experiment Overview, Scientific Results and Future Directions. Journal of Geophysical Research 102(D24): 28,731-28,770.

17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

None.

19. List of Acronyms

ASCII	- American Standard Code for Information Interchange
BOREAS	- BOReal Ecosystem-Atmosphere Study
BORIS	- BOREAS Information System
CD-ROM	- Compact Disk-Read-Only Memory
DAAC	- Distributed Active Archive Center
EOS	- Earth Observing System
EOSDIS	- EOS Data and Information System
GIS	- Geographic Information System
GSFC	- Goddard Space Flight Center
HTML	- HyperText Markup Language
NASA	- National Aeronautics and Space Administration
NSA	- Northern Study Area
OA	- Old Aspen
OBS	- Old Black Spruce
OJP	- Old Jack Pine
ORNL	- Oak Ridge National Laboratory
PANP	- Prince Albert National Park
PPFD	- Photosynthetic Photon Flux Density
RH	- Relative Humidity
SSA	- Southern Study Area
TE	- Terrestrial Ecology
UBS	- Upland Black Spruce
URL	- Uniform Resource Locator
UTM	- Universal Transverse Mercator

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